Application of Precast Aerated Concrete Panel Used as External Wallboard in China

Pengxuan Duan[1], Ye Zhang[*2], Xiaoqun Zhou[3],Yuanchao Miao[4]

National Key Laboratory of Solid Waste Resource Utilization and Energy-saving Building Materials

Beijing Building Materials Academy of Sciences Research

Beijing Office of Wall Materials Innovation

Jin Ding North Road No.69, Shijingshan District, Beijing, 100041, P.R China

[1]dpx2003@aliyun.com; [2]zhangye_001@home.ipe.ac.cn; [3]zxq9999@sina.com; [4]miaoyuanchao@bbma.com.cn

Abstract

The paper studies the performance of precast aerated concrete panel and its matching mortar. In addition, the application mode and characteristic of the precast aerated concrete panel used as external wallboard are also discussed. The results show that the specification of precast aerated concrete panel with 300 mm thickness and 400 Kg/m^3 used as the external wallboard can reach the heat transfer coefficient of reducing 75% energy consumption. Furthermore, with the improvement of Chinese energy-saving requirements, precast aerated concrete panels used in the external wallboard of residential buildings will be more and more.

Keywords

Precast Aerated Concrete Panel; External Wallboard; Energy-saving; Matching Mortar

Introduction

The main materials of aerated concrete panel (AAC panel) are silicon sand, cement, lime etc. Reinforced with anti-stain processed steel bar, the concrete panel with many air holes was formed after high-temperature, high-pressure protection with steam. It has the properties of light-weight, thermal insulation, fire resistance, sound proof, solid waste application and convenient construction. It is a new type of construction material with excellent functions and performance. Mostly, the precast AAC panels are used as inner wall board, roof board, external wall board, minimum span floor and other places.

Properties of B04 AAC Panel

Mechanical Properties of B04 AAC Panel

According to China's national standard for AAC, the mechanical properties of the studied precast AAC panel of B04 ($\rho \leq 425 kg/m^3$) are illustrated in Table 1.

TABLE 1 MECHANICAL PROPERTIES OF B04 AAC PANEL WITH THE THICKNESS OF 300MM

No.	Technical properties	Unit	Standard index	Measured data
1	Density, kg/m^3	Kg/m3	≤425	410
2	Compressive strength, MPa	MPa	≥2.0	3.0
3	Heat transfer coefficient, (W/m^2·K)	W/m.K	≤0.12	0.10
4	Impact	times	≥5	No destruction
5	Single point hanging	N	≥1200	1200
6	deflection	mm	—	0.66
7	Bending load	N/m^2	—	8400
8	Heat transfer coefficient	W/m^2.k	—	0.38

According to Table 1, the mechanical properties of B04 AAC panel meet the needs of the building external wall in the north of China. The mechanical properties of B04 AAC panel with the thickness of 300mm meet the qualification of autoclaved lightweight aerated concrete Edition (NALC) Construction Detailing (03SG715-1). The determined results mentioned above show that B04 AAC panel can be used as the energy-saving building external wall in the north cold region of China.

Thermal Performance of B04 AAC Panel

According to Chinese national standard "Thermal insulation--Determination of steady-state thermal transmission Properties-Calibrated and guard hot box", the heat transfer coefficient of B04 AAC panel with different thickness are measured. The specimen for the heat transfer coefficient determination is made of three splicing B04 AAC panels. The joint of panels are full of special mortar with 3mm thickness. Then, the treatment of the inner and the outer surface of the specimen are covered with special mortar for AAC

panel. The experiment results indicate that the heat transfer coefficient value of B04 AAC wall of 300mm thickness is 0.38 W/(m²·K) and meets the requirement of the heat transfer coefficient limit (0.45 W/(m²·K)) which indicates reducing energy consumption to a higher level of high-rise buildings in China.

Properties of Matching Mortar for AAC Panel

Characteristics of Plastering Mortar for AAC Panel

AAC itself has high porosity, slow water absorption rate and its voids are mostly in elliptical-shaped structure. The continuous water absorbent of AAC masonry has great impact on its plastering construction. Moreover, the AAC masonry itself has lower strength and elastic modulus, compared with the mortar which has higher strength and elastic modulus. The difference of strength and elastic modulus between AAC and plastering mortar can produce higher shear stress and lead to destroy of the interface. So there must be a good consistency in strength and elastic modulus between AAC masonry and its special mortar. For example, the value of AAC compressive strength is in the range of 2.5-4.0 MPa, thus the value of special mortar compressive strength should be in the range of 4.0-7.0MPa.

Preparation of Plastering Mortar for AAC Panel

TABLE 2 PROPERTIES OF AAC PLASTERING MORTAR

No.	Water retention (%)	Compressive strength (Mpa)	Elastic modulus (N/mm²)
1	83.08	4.47	1608
2	86.33	6.94	1750
3	90.19	7.18	1987

The properties of prepared plastering mortar are shown in table 2. As table 2 showing, the compressive strength value and elastic modulus value of prepared AAC special mortar are respectively in the range of 4-7MPa and 1600~2000N/mm². This matches the compressive strength and elastic modulus of AAC very well. In addition, the water retention rate of this prepared plastering mortar is 80% and it is suitable for the application of thin or thick plastering of AAC masonry.

The results of experiments using AAC blocks as substrates indicate that the prepared AAC plastering mortar has a good bonding property for AAC blocks produced from different factories. The destruction surface mostly occurred in the AAC itself under the condition of tension test (Figure 1). And fewer destruction sites appeared in the interface of mortar and AAC or in the mortar itself (See Figure 1). The tensile and bond strength increases with the increase of bulk density of AAC.

FIG. 1DAMAGE PATTERNS OF AAC BLOCK

Precast AAC Panels Used as Building External Wall

Advantages of Precast AAC Panel Used as Building External Wall

Compared with other insulation systems, the precast AAC panels used as protective-enclosing structure material for the AAC insulation system have significantly technical and economic advantages.

In the AAC panel insulation system, the insulation constitution design is relatively simple because of its having the advantage of integration of insulation and structure. In addition, the different density and thickness AAC panels can be chosen according to different energy-saving demands.

Compared with block filler wall, the external wall made of AAC panels have the advantage of fewer mortar joints, no effect on heat bridge resulted by ring beam and constructional column. And the energy-saving demand can be easily reached by using the AAC panels. Moreover, the wall has good impermeability, air tightness and integrity.

The precast AAC panels as protective-enclosing structure material for the AAC insulation system have the property of light weight, which reduces structural cost and the danger and damage of earthquakes.

The AAC insulation wall has good durability and weather ability, and its fire resistance can reach six hours.

The AAC panel used as building external wall has a complete specification system including standard and atlas. This is favorable to housing industrialization which emphasizes standard design, factory-made and assembly construction.

Early Application Examples of AAC Panels

In the 1970s, the application of AAC panel as building external wall has emerged in Beijing. In these buildings, the building structure is mainly AAC panel filled reinforced concrete frame-shear structure. The panels can be installed in both vertical and lateral direction. And also, they can be assembled as large panel in factory before use. The main construction processes includes pouring ground, lashing steel of internal wall, assembling concrete templates, assembling AAC panels, pouring concrete, lashing steel of ring beam joints, pasting insulation blocks on the ring beam, pouring slab joints, concrete of ring beam and finally pouring ground concrete.

Examples for Vertically Assembling Precast AAC Panel

(A) CONSTRUCTION TIME: 1975 (B) CONSTRUCTION TIME: 1976

FIG.2 RESIDENTIAL BUILDING WITH VERTICALLY ASSEMBLING AAC PANEL

The building of Fig. 2(a), which has 9 floors is located in Xicheng district, Beijing. It was designed in 1972-1973 and completed in 1975. The B05 AAC panel with 200mm thickness has been vertically installed. The building has been in use for 30 years and it is still in good condition.

The building of Fig.2 (b), which has 12 floors is located in Dongcheng district, Beijing. It was designed in 1974-1975 and completed in 1976. The B05 AAC panel with 175mm thickness has been vertically installed in the form of two panels stitching. The building has been in use for 30 years and it is also still in good condition.

The AAC panel vertically assembled is by means of combining the steels stretching out of panels with inter-layer beam or floor. The vertically assembled wallboard can be installed in single or two stitching panels. The slab joints must be full of adhesive to guarantee good permeability. This kind of stitching method is better than pouring joints because of the squeezing effect of slab self weight.

It is noting that the wallboard should have strong links with main structure of buildings to avoid the slab being thrown under the condition of earthquake. And the installation program is an emphasis in the construction process of wallboard and main structure.

Examples for Lateral Assembling Precast AAC Panel

In 1975-1976, several industrial plants were built. In these buildings, the AAC panels are arranged laterally. Now, the plants have already been removed, leaving no picture information.

Transverse arrangement is generally used framework for industrial plants, of which the column spacing is within 6m. In this arrangement, both ends of the plate link with the frame columns. The arrangement characteristic of the general industrial plant is one layer of wall and one layer of window. The layout is favorable to design and construction convenience. The nodes of the transverse arrangement are structural steel columns, steel roof trusses inside and externally using AAC panels with length of 4800mm, thickness of 175mm, the joints of horizontal plate with two rubber strips, sew the ends covered with a thin-walled steel joints, galvanized iron Paper do outside windowsill. After years of tests, this construction method, both in solid and reliability, and waterproof effect, has no problem.

Examples forAAC Panels Externally Hhung on the Main Structure

In recent years, with the improvement of Chinese energy-saving, Anthe use of the precast AAC panels in modern buildings is also increasing. The precast AAC wall panels are usually used as an enclosing structure material in frame structure or frame - shear wall structure.

The AAC panels in these buildings can either be vertically or lateral installed. They are always externally hung on the main structure and its nodes design are significantly different from that in the buildings in the 1970s.

Connections for Precast AAC Cladding Panels

FIG.3 FIXED TOOLS FOR AAC CLADDING PANELS (LEFT: SPECIAL PALLET; RIGHT: HOOT BOLTS)

The installation connections are the main components for AAC cladding panels secure installation. They are special pallet, angle, hoot bolts and other connections (see Fig. 3). The bottom of AAC wall board is situated on a special pallet fixed with the main structure and the upper of AAC wall board fixed by the bolts which are welding with the angle fixed with the main structure.

Industrial Construction Examples for Precast AAC Cladding Panels

The precast AAC cladding panels used in industrial constructions are always B04 AAC panels with 250mm or 300mm thickness (see Fig. 4).

FIG.4 CONNECTION OF AAC PANELS WITH MAIN STRUCTURE

Conclusions

The paper studies the buildings in 1970s which is early built in reinforced concrete filled with AAC panels. These buildings are in good condition, which identifies that the AAC panels have better durability and weather ability. It is noting that there are some cracks appeared on the wall surface of the buildings, because of the mismatching mortar or incorrect installation method. The problems mentioned above can be resolved by special mortar for AAC and advanced joint design.

In this paper, the heat transfer coefficient of B04 AAC panel with 300 mm thickness can reach the demand of reducing 75% energy consumption. Considering the feasibility of production, transportation and easily installation, the B04 AAC panel is a good choice as a kind of building enclosure structure material to achieve higher energy-saving demand.

Currently, the production of AAC panels in China is only about 500000 m3. And they mostly are used in wallboard and inter board of public constructions having large span, such as storehouse and workshop. With the increasing demand of insulation and fire resistance, the AAC panels will be used more and more in the middle and high rise residential buildings. In addition, the promotion of housing industry and building industrulization also give a good chance to promote the application of AAC panels.

ACKNOWLEDGMENT

This work was financially supported by the National Science and Technology Infrastructure Program (2012BAJ20B04-04).

REFERENCES

Pengxuan Duan. " The Research on the Production of B04 AAC." Beijing Building Materials Academy of Sciences Research, 2010.

Peiming Wang. "The Progress of Dry-mixed Mortar in China and the Effect of Polymer-modified Morar." Paper presented at the annual meeting for the Technical Seminar of Dry-mixed mortar in China, Beijing, 2004.